ON NODULAR DISEASE OF

THE INTESTINE IN SHEEP

BY

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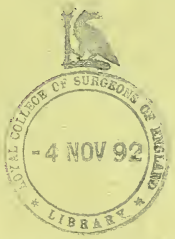

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On nodular disease of the intestine in Sheep.

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IT is an unfortunate fact that the rearing or keeping of sheep is next-door to impossible, either in Assam or Burma.

In both these localities mutton is a sort of exotic luxury, obtained at much expense by importation from India.

The supply of Rangoon, for example, is regularly brought over in the weekly B. I. boats, and, in Assam the butchers march sheep up from Bengal in comparatively small batches, and dispose of them as quickly as possible. Naturally, owing to the animals being slaughtered immediately after so severe a march, good bazar mutton is practically unobtainable; and hence, wherever the European population is sufficiently numerous, "mutton clubs" are formed, which import sheep, and fatten them up as rapidly as may be, for the table.

Not unfrequently, however, these co-operations fail owing to large losses of their sheep.

It is needless almost to say that these losses are always ascribed to that favourite scapegoat for hazy sanitarians—*climate*; though how or why the climate of the Indo-Chinese peninsula should be particularly prejudicial to sheep I cannot remember any one attempting to explain.

The explanation I have now to offer refers the mortality ultimately, it is true, to climatic conditions; but it has the advantage of explaining how and why the climate acts prejudicially, and therefore of showing us in what direction we may best take preventive measures.

The fact is that the prolonged dampness of these climates is peculiarly favourable to the welfare of the free stages of nematode parasites, many of which are particularly fatal to cattle in general, and to sheep and solidungulates in particular. Of Burma I can say but little, and can only judge from a few reports from others, and from the probability afforded by similar climatic conditions; but, with regard to Assam, I can, from personal observation, answer for the fact that its climate forms a sort of paradise for parasites.

I examined, in connection with my investigation of Kala-azar, the carcases of several species of animals; and not only every species, but every individual, was found to harbour more or fewer species of entozoa, many being perfect miniature

helminthological museums. The leading fact brought out by my investigation of *Dochmius duodenalis*[1] in the human subject, of *Sclerostomum tetracanthum* in horses, and of the present investigation, is that the persistently endemic presence of the diseases to which these parasites give rise is owing to the circumstance that all these species are capable of living and breeding freely, indifferently as entozoa or as free living animals; and, further, that these free-stage nematodes possess wonderful powers of resistance to adverse conditions. Their great enemy is drought. It is true that they are capable of passively resisting it; but they can only oppose it by retiring to a sort of condition of suspended vitality, and cannot flourish and multiply as they do when favoured by damp surroundings.

The free-stage "rhabditis" of *Dochmius duodenalis* cannot, for example, resist prolonged exposure to the full heat of the sun, but they can remain dried up, but still alive, in moderate shade for an indefinite period; and it is probable that the same is the case with the free-stage generations of allied species, though I have no direct observations to adduce in their case as I have in the case of the *Dochmius* rhabditis.

Periods of drought are, however, periods of suspended vitality, if not of infectiveness. The chances of infection for the host depend entirely on the opportunities of multiplication enjoyed by the free generations; and, in the case of those of *Sclerostomum tetracanthum*, recently described, and of those of *Œsophagostomum columbianum*, on the consideration of which we are about to enter, the opportunities of multiplication may be said to depend entirely upon the character of the weather; as not only are they unable to breed except in damp surroundings, but their supply of suitable food depends on the same conditions.

Few climates can offer these conditions in greater perfection than that of Assam. The protracted period of the rains, lasting practically from March to November, is immediately succeeded by a cold season characterized by heavy fogs, which, commencing long before dawn, last often well on towards noon, and which so thoroughly saturate the soil and herbage that a stranger would imagine that a heavy shower had fallen during the night. Practically February and a portion of March are the only months in which, ordinarily, the soil has a chance of drying, and this period is quite insufficient to do much harm to the free-generation nematodes, save in situations where the soil is absolutely open and bare, which, in such a climate, are naturally few and far between. Given then the presence, in such a climate, of a parasite inimical to the life or well-being of any animal, and it may be taken as certain that that animal will be unable to thrive there.

Thus, though my deductions, in the present case, are founded on an isolated observation, I feel convinced that further investigation will show that the reason of the difficulty of sheep-keeping in Assam may be considered as solved.

The disease is moreover to be met with, to a less virulent extent, in the Punjab.

[1] Report of an investigation into the causes of the diseases known in Assam as Kala-azar and Beri-Beri.—Assam Secretariat Press, 1890.

Shillong is as badly off for mutton as other parts of Assam, the bazar supply being often uncertain, and uniformly poor. Under these circumstances, a mutton club of some sort is a necessity, and during the season of 1890 a sort of Proprietary Club for the purpose was started by Mr. Fenton, the enterprising Manager of the Shillong Hotel; the "Club" element being, however, represented only by a number of residents undertaking to take the mutton, while he incurred all risks.

Grazing being abundant and excellent, he got up from Bengal a considerable number, and, by a liberal supply of grain, succeeded for a while in supplying excellent mutton.

After about six weeks, however, the quality began to fall off, till, in another month, he was obliged to suspend his supply, no sheep remaining in a fit condition to kill.

Then the sheep began to die off, not in numbers at a time, but one by one.

The animals did not appear to be in any suffering, but were feeble and dejected looking, though they eat greedily till nearly the end. The supply of grass was unlimited in quantity and good in quality, and, in addition to this, they were given a liberal ration of grain. They were well housed, at night, in a large shed, the floor of which was raised on poles several feet above the ground. Their water-supply was above suspicion. Yet, in spite of such exceptionally favourable conditions, the leading symptom of the epizootic that was frustrating all Mr. Fenton's efforts to supply us with good mutton was a slow and progressive wasting. In advanced cases an examination of the mucous membranes of the conjunction and mouth showed them to be singularly bloodless, though, perhaps, hardly so markedly so as in the case of the horses affected with sclerostomiasis described in the preceding paper. Death was usually ushered in by scouring; but this symptom was characteristic only of the end of the case, and was by no means invariably present.

Sometimes the wasted animal would be only "off its feed" for a day or two, and then be found dead in the morning.

My attention having been so forcibly drawn to helminthiases as a cause of mortality among men and mules, I naturally suspected that such similar symptoms among sheep might be due to a similar cause, and accordingly I proceeded to examine the droppings of the affected flock. The specimens were taken at random from the floor of the hut, and, without exception, every nodule was found to contain immense numbers of characteristic strongyle ova.

It was clear that more than one species was present; but the dominant species was one which produced somewhat oblong ova, intermediate in size between those of *S. tetracanthum* and *D. duodenalis*, and measuring, in fact, about 0·082 mm. in length by 0·047 mm. in width.

From nodules selected as containing only the ova of what I may call the dominant parasite, I instituted some cultivations. These were conducted by

simply breaking down and slightly damping the nodules, placed in a crystalizing glass, and covered to prevent evaporation. I succeeded in following their development under these conditions further than I was able to in the case of *Sclerostomum tetracanthum*, as they had advanced well on to the sexually mature condition, and had developed the peculiar styliform mouth armature before the conditions became too unfavourable for further development. It would be a mere waste of expensive lithography to figure these, as they are almost identical in appearance with the free stage of *S. tetracanthum* already described and figured, and differ only in some minute details, which pressure of work at that time prevented me from minutely noting. There can, however, be no practical doubt that, in order to attain complete sexual maturity, they require to gain access to the forage plants which supply them alike with food suitable for their free-stage life, and the opportunity of infecting new hosts for their parasitic generations.

Under these circumstances I urged Mr. Fenton to send me the carcases of some of the dead sheep for examination; but, one way and another, it was not until July that I obtained the opportunity I required.

I extract from my diary a brief account of the examination.

Carcase, poor; flesh, watery; mucosa, pale. Lungs, some congestion at bases (mainly hypostatic), freely crepitant throughout. In bronchi I found four specimens of *Strongylus filuria*, Rud. (a number inadequate to do any particular harm). Heart, liver and spleen healthy. Intestinal canal—stomach The rumen contained large numbers of *Amphistomum conicum*, Rud. In addition to these, a few specimens were found of a filiform nematode about 9 c. m. long, which appears new to science. (A description is appended.) Only female specimens were found; but some were present in all divisions of the stomach, except the reticulum. Small intestine—dotted throughout its length with small nodular tumours, varying in size from a pin's head to that of a large pea. The larger tumours are full of greenish caseous matter, and mostly contain no worms: the smaller ones contain each a minute, sexually immature nematode, with cup-shaped mouth cavity.

Throughout the entire length of the small intestine, becoming more plentiful in descending, were found considerable numbers of a small strongyle. (This appears to be hitherto undescribed, and a description is appended under the name of *S. colubriformis*.) Large intestine dotted throughout its length with nodular tumours, like those seen in the small intestine. In addition were found free, large numbers of another strongyle, near *S. tetracanthum*, which I could not then identify, but which, without doubt, was the adult stage of the tumour-producing immature worms, and the efficient cause of the death of this sheep, and doubtless of the epizootic generally. Many thousands must have been present; but their numbers still could not approach those in which I had found *S. tetracanthum* in equines.

The scanty literature I possessed contained no reference to it, and I was just going to write to my long-suffering friends at the Indian Museum, to beg them to search out for me any references there might be to new ovine nematodes that might have been described, with the view of describing it under the name of *S. orientale*, should it prove to be new, when I met with, in the current "Journal of the Royal Microscopical Society," a notice of a work by Dr. Curtice, of Washington, United States of America, monographing the animal parasites of sheep, and determined to hold my hand till I could obtain a copy. The work is published by the United States Bureau of Agriculture, and I had some difficulty in getting one. It is as well, however, that I delayed, as I found my worm described in it as a new species, which would have had a priority of several months to any description I might have publishe d.

Nodular disease of the intestine had been, it seems, known as a widely-spread and fatal disease among sheep in America for many years, but investigators had wasted their energies in fruitless searches for the tubercle bacillus; and it was reserved for Dr. Curtice to demonstrate the true cause of the disease, an achievement which he looks upon as the most important outcome of a long and exhaustive investigation into the ovine helminthology of North America.

His descriptions and observations generally coincide exactly with my own in every particular, except that he is unaware of the existence of a free stage to the worm, and assumes that sheep are directly infected by swallowing the ova. My measurements of the ova give a somewhat smaller figure than his; but I notice that this is the case also with the ova of other parasites which we have both measured; so that it is probably due, not to any difference in the material observed, but to some error in the methods employed by one or the other of us. My own measurements were taken by comparing the size of a camera lucida drawing of the ova with that of a micrometer scale, the two drawings being made under absolutely unchanged conditions, the micrometer being merely substituted for the slide, and its divisions drawn beside the outline of the preparations. The accuracy of the micrometer employed was also tested by comparing a drawing of it under a low power with those of an actual full-sized engineer's scale; so that I see little room for error in my determination, and am inclined to prefer them to those of Dr. Curtice, who may have employed merely the eye-piece micrometer, an instrument which is apt to give only approximate results, small differences in the focussing of the eye-piece scale leading to perceptibly discrepant results.

The description below is taken from Curtice, but with some minor additions. *Œsophagostoma columbianum*, Curtice.—*Description.*—Male, 12 to 15 mm. long; female 14-18mm. (Curtice.) (I have a female specimen measuring 22 86 mm. or 0·9″). Body, of nearly uniform diameter throughout, tapering abruptly at head and tail. Greatest diameter, in both sexes, about middle of body-length;

[1] United States Department of Agriculture, Bureau of Animal Industry:—"The Animal Parasites of Sheep," by Cooper Curtice, P.V.S., M.D.—Washington, Government Printing Office, 1890.

0·56mm. in female ; 0 44mm. in male. Head usually bent down, often into the form of a hook. Papillæ six, of which two are dorsal, two ventral, and two lateral : the latter are more obtuse, and are the openings of the lateral canals. Mouth terminal, provided with a chitinous armature, consisting of an annular ring, supporting two systems of 24 teeth each (Curtice). My own observations lead me to believe that the armature is more complex than this, and that there are three rows of differently-shaped "teeth." The complexity of the object, however, renders its resolution, even with high powers, a very difficult matter, especially as the images of the various rows of teeth are further confused by a radiate ribbing of the chitinous lips, so placed that each rib is opposite a set of "teeth." The innermost row have a very characteristic bidentate form, while the second are long and slender, and have the form of a linear-lanceolate leaf, with the proximal portions of the margins rolled in towards the midrib.

These fimbriæ, by their convergence, form a sieve, exactly similar to that described in the equine sclerostomes, and, external to them, and corresponding in position to the trephine circlets of *S. equinum* and *robustum*, I make out a circlet of short teeth, with semi-lunar margins. The circumference of the mouth is curiously ribbed, the ribs being equal in number and opposite to the tooth systems, and it is, I think, from confusing the image of this ribbing with the overlying triphine teeth that this circlet has been overlooked by Dr. Curtice in his description. Immediately beneath the ring supporting the bidentate teeth is the triradiate opening of the œsophagus, no chitinous buccal cup intervening, as is the case in the allied genus *Sclerostomum*. Neck, not inflated, but provided with a lapel or cuticular fold, on the ventral aspect, just in front of the ventral cleft ; the fold continues slightly on the dorsal aspect. Two lateral, narrow, membranous wings begin at this fold, and continue for one-fourth the length of the worm. The two lateral opposite papillæ are in these wings, at the level of the first third of the œsophagus. The pair of unicellular neck glands (lemniscus) unite into a common duct and empty at the ventral cleft, situate beneath the median fold. Male, about three-fourths the length of the female. Bursa can, with difficulty, be spread without tearing. It is slightly prolonged dorsally, but notched in the middle line so as to indicate a primarily bilobed arrangement ; ventral cleft shallow. Costæ symmetrical, the ventral slightly separated ; the dorsolateral forms with its fellow and the dorsal pair a group ; dorsal rib bifid ; the divisions widely separate at free ends. Spicula two ; subulate, bordered by a very narrow membrane ; the chitinous cylinder is apparently fenestrated. At either side of the genital aperture are two knobbed papillæ. Female, relatively stouter ; vulva just in front of anus, which is close to the mucronate tail ; usually covered by a brown crust, consisting of ova glued together by mucus ; reproductive organs in two symmetrical sets anteriorly directed, except a small portion of one which loops backwards in front of the anus. Uteri caudally placed ; can be followed to ovaries, which continue forwards to œsophagus, below which they are reflected to form a loop, reaching

nearly to the vulva to form yet another loop. Ova laid as a gastrula; length, 0·082 by 0·047 mm. (0·09 by 0·05 mm., Curtice).

Life-History.—The similarity between *Œsophagostoma columbianum* and *Sclerostomum tetracanthum* in anatomy and life-history, in all points that are certainly known for both is so close that there can be no practical doubt that the two histories are in all points identical.

The ova of the present species hatch out the first or second day after the deposition of the dung. Shortly after their escape from the egg they can be found in the moistened dung as immature rhabdites 0·5 mm. in length by 0·03 mm. at their greatest thickness. At this stage the digestive organs alone are developed. The œsophagus is provided with two bulbs, the upper of which, however, is very indistinct, while the lower is thick and globular, and provided with a distinct chitinous armature. The tail is short, and rather abruptly tapered, and has no long lash, such as characterizes the rhabditis of *S. tetracanthum.*

When first observed, I was closing up my laboratory work at Shillong and had no time to devote to experiments which would probably last through several months. Now that I have a fresh supply of material, the temperature of the air appears to be inimical to their progress, as but few have hatched out. I hope, however, to be able to follow out the subject more closely during the favourable period of the next rains. I have, however, followed them until they were far on to the mature rhabditis stage, the generative organs being already well outlined, though not as yet sexually distinct, and the mouth having acquired the peculiar hollow-style armature which I have described and figured from *S. tetracanthum.* After leaving the dung, like the rhabditis of that species, they doubtless climb on to succulent forage plants, on the juices of which they feed by means of their sharp, hollow, protrusible style. Here they attain sexual maturity and multiply for more or fewer generations. If now some of these rhabditis progeny be swallowed by sheep along with their food, their next step is to bore into the intestinal submucosa and there to encyst themselves. Thus situated, with an abundance of nourishment all round them, they grow rapidly to a size many times exceeding that of the free generations, and, when ripe to attain sexual maturity, they bore their way back into the intestine, and, by a series of moults, gradually acquire their peculiar mouth armature, become sexually mature and lay, with the dejecta of their host, the immense number of eggs which are destined to start the cycle of life afresh.

Dr. Curtice states that the worms moult at least three times during its (parasitic stage) development, but on this point my observations have been too desultory to be of value.

He indicates also his belief that the worms do not always encyst, but may undergo all their changes within the intestine, basing his opinion on the fact that large numbers of free adults were found in a lamb only a few weeks old, in the intestine of which only a few small tumours could be found. It is, of course,

quite possible that this may be the case; but it appears *a priori* improbable, and I should rather be inclined to attribute the absence of large tumours to their having been re-absorbed, a process which would naturally take place with exceptional rapidity in so young an animal.

An examination of sundry specimens of grass, not known to be infected, has led me to the suspicion that many of the free living nematodes which may be found in such situations and which have hitherto been regarded as distinct species, may be but free-stage examples of certain parasites. In the determination of this point, I believe that a comparison of the ova of mature specimens will be of the greatest value, as in the two examples I have hitherto investigated the one point of resemblance between the free and parasitic generations was the absolute anatomical identity of their ova. It need not, of course, follow that because the normal method of infection is, by the ingestion of embryos, indirectly descended from parasites, that the swallowing of direct descendants would be unattended with risk. Indeed, the more I consider the matter the more I am led to the conclusion that it is a matter of absolute indifference to the just hatched embryo whether it finds itself in free or in parasitic surroundings, or whether it be the direct progeny of the parasitic or of the free stage. The ova probably, however, cannot hatch out in the absence of oxygen as, for example, would be the case if swallowed. The only difference would be that, by affording these different surroundings, two brother emrbyos might be made to develop respectively into the widely different free and parasitic mature adults. The actual demonstration of this by experiment would be fraught with difficulties, and could only be accomplished on an experimental farm. One would have, to begin with, to raise some stock absolutely free from parasites, and widely distributed as these now are, one would have to take lambs as soon they were dropped, and to artificially feed them, throughout their life, with milk, and afterwards with fodder which had been raised to a sufficient heat to destroy all parasitic life. That this is no exaggeration is shown by the fact that I have never, in India, thoroughly examined the carcase of any mammal without finding entozoa.

It is obvious that this power of being able to live and breed indifferently, either as free nematodes or as parasites, adds immensely to the power of the species to perpetuate itself.

Pathology.—Once one's attention has been directed to the matter, it is impossible to mistake the appearances presented by this disease for any other condition, except perhaps tubercular disease of the intestine, which is, however, I believe, rare or unknown in sheep. The larger tumours form coarse, naked-eye lesions, which can be seen and felt as hard opaque nodules, even in the unopened intestine, but can best be studied by slitting it open, and, after thoroughly washing it, holding it up to the light, when even the smallest tumours stand out as opaque dots. To make matters certain, stretch a piece of intestine containing a medium-sized tumour over the tip of the finger and snip out the tumour with a pair of scissors curved on the flat.

Place the morsel of tissue in a shallow glass tray of water under a simple microscope. Then slit the tumour with a fine knife under water, and press out its contents with the flat of the blade. By a little teazing of the cheesy mass, it is then quite easy to separate the little worm, which is quite large enough to be easily visible under a power of eight or ten diameters.

The tumours will be found scattered over the whole length of the intestine, but become more numerous as one descends, and are most plentiful of all in the cœcum and upper part of the colon, ceasing to be found about that part of the large intestine where the nodular dung commences to be formed. Below this I have not found them, and I have not as yet positively demonstrated their presence in the stomach, though, from some appearances met with in the absomum of one carcase that I have examined, I am inclined to believe that they will ultimately be found to occasionally encyst themselves in that organ.

The little worms are enclosed in a sort of cyst, which is especially easily demonstrable in the smaller tumours, and, in addition, there is a sort of second cyst to all, formed by inflammatory infiltration of the surrounding tissues. In the larger tumours the worm itself and its proper cyst forms but a very small proportion of the contents, by far the greater bulk being made up of thick cheesy material, the greenish colour of which clearly shows it to consist of altered blood clot. In the very largest it will nearly always be found that the worm has escaped, and yet another category will be found, of medium size, in which the worm has also escaped, but which differ from worm-holding tumours of the same size by their dark, brown colour, and shotty feel. These are tumours in the course of absorption, and, in some, the addition of dilute acid will demonstrate the fact that their contents have undergone calification. The natural course of events lies in the direction of absorption of the contents of the tumour, or their reduction to calcareous nodules and recovery; but when the health of the host is too far undermined to admit of this, or when, perhaps, there is some special septic infection of the puncture made by the worm, the tumour will break down, and leave a small, circular, undercut ulcer. This was the case in nearly all the larger tumours found in the first carcase examined at Shillong, and, in spite of their individually small size, their large numbers were quite sufficient to account for the dysenteric symptoms that ushered in the animal's death.

The worm found within the tumours is sexually immature, and differs entirely in appearance from the adult, the mouth parts never attaining adult characters, as is done by *S. tetracanthum*. In the larger ones, about the middle of the body, may be made out a spindle-shaped mass of protoplasm, which is the rudiment of the generative gland. The description of them, given below, is from Curtice:—

"From 0·23 mm. upwards. The largest found in tumours were 4 mm. long; the smallest male, found in intestine, being 7 mm. long. The smallest embryos were without digestive apparatus? ? The largest possessed an intestine, unicellular glands (lemniscus?

G. M. G.), and a well-formed, chitinous, cup-shaped oral aperture; also six cephalic papillæ, and at the neck two papillæ, and a well-defined fold."

I am inclined to believe that the observation as to the absence of digestive apparatus is erroneous. I have watched many embryos of this species as they issued from the egg, and have always been able to make out an already well-developed digestive tract, with a double bulbar apparatus, even in those that had but just wriggled out of the egg-shell. One often sees similar notices with regard to other nematodes, and I have met with specimens where, at first sight, I could make out no digestive organs, but by careful examination and the use of suitable re-agents have always been able to prove my first impression to be wrong. I believe most of these false observations arise from the unchecked examination of balsam and glycerine mounted specimens, media which quite obliterate fine details for thick specimens. They are best examined in water, and the addition of a little suspended carmine to the water containing living specimens will often show up the intestine. Failing this, the addition of a small proportion of alcohol may be tried, or tear up a specimen with needles and stain with borax carmine or picrocarmine. Without previous slitting or tearing, it is useless to attempt to stain, as the impermeable chitinous cuticle entirely prevents the stain from reaching the organs which it is desired to differentiate.

If the newly-hatched embryos have well developed digestive organs, it is *a fortiori*, highly improbable that the much older encysted worms should have these organs undeveloped, and I certainly have not met with any such.

His minimum measurement too appears to me curiously small. Embryos fresh from the egg are larger than this.

The adult worms are found exclusively in the large intestine, and, so far as I have seen, their favourite residence is some distance along the colon, but few, as a rule, being found in the cœcum. The only ovine parasite they are likely to be mistaken for is *Dochmius hypostomus* Diesing, which, being about the same size, and having the same habitat, is easily confused with it. *D. hypostomus*, however, averages larger, in all dimensions, and may be further distinguished by the more distinctly globular form of the head, which forms quite a knob at the end of its body, and the form of the male bursa, which has an elongated, instead of a transversely oval, outline.

I am doubtful whether our species has the habit of blood-sucking. I have not yet met with them actually hanging on to the mucous membrane; but this may be owing to my never having examined a warm carcase. However that may be, it may be considered certain that the harm they do as adults is small compared with the mischief effected during their stage of encystment.

From the fact that the number of free adults found is generally small in comparison with that of the tumours, it is probable that the period of their stay within the intestine is comparatively short, and that they rapidly discharge their generative products, and are then extruded with the dung.

The harm done by the encysted worms, on the other hand, must be ex-

tremely grave. The lesions produced are practically identical with those of intestinal tuberculosis, and, from our experience of human pathology, we well know how dire a disease is that.

It must be remembered that the worm makes its puncture from a cavity full of various septic germs, and hence that the wound so produced must always be a septic one. Witness the foul character of all suppurations that take place in the neighbourhood of the digestive tract. Further, the resorption of the cheesy matter is certain to be attended with further sepsis, and recovery can only be gained by its absorption.

In this, as in most other helminthiases, it must be remembered that the element of number is most important. Short of some accidental septic infection of the punctures by some poison of exceptional virulence, it is inconceivable that any perceptible harm should be caused by a dozen or so of encysted worms; but, on the other hand, it is equally impossible to imagine that any considerable number can be present without gravely affecting the health of the host; or that, beyond a certain limit of number, determined by individual resisting power, the continuation of its life should be possible.

The sheep I examined at Shillong, *e. g.*, had passed that limit, while those I have examined at Sanawar were carcases taken at random from the ration stand, and were not affected to a fatal extent.

The ration mutton here is extremely poor, and it is by no means easy to obtain really prime meat, even by paying a high price for so-called gram-fed mutton. In the carcases, moreover, that I have examined, the poorness of the carcase was distinctly proportional to the severity of the infection, while the full maws of the animals further showed that this poorness was not to be accounted for by scantiness of food supply; and it is to be noted that the examinations were made just after the end of the rains, when the grazing had been for months plentiful. Now, as it is impossible to believe that such grave lesions can exist without seriously affecting the health of the animals, I think it may be taken as proved that the poorness of the meat is mainly caused by the parasite under discussion. At the same time it must be remembered that other parasites help in producing this wasted condition, and, in some cases, have more to say in the causation of the leanness of the meet supply than *Œsophagostoma columbianum*. A very large proportion of the carcases, *e.g.*, show numbers of cysts (*Tænia echinococus*), the liver and lungs being often absolutely riddled with them. In one case two or three minute embryos could be found in almost every section of the viscera, the sections being not more than $\frac{1}{4}$th inch square and less than $\frac{1}{1000}$ inch thick.

Ruminants appear to suffer much less injury than man from harbouring this parasite; but when matters go to such an extent, health is clearly impossible to the host.

Intestinal (adult) tapeworms are also almost universally present. *Tænia*

expansa in some, and another smaller tape worm, which I have not yet been able to identify, in nearly every case; and these too no doubt help to swell the mischief. At the same time, making all allowances for the influence of these parasites, it is, I am convinced, to the ravages of *Œsophagostoma columbianum* that the poorness of our supply of mutton is mainly due.

It is remarkable that, out of over a hundred animals examined, I have never in the Punjab met with either of the two lung strongyles which are so destructive to sheep in some parts of the world.

Diagnosis.—For the stock-keeper the only symptom will be wasting, followed perhaps by diarrhœa, often of a dysenteric character. The existence of such symptoms in animals inhabiting any region known to be infected by this parasite should at once arouse suspicion, and the diagnosis can easily be confirmed by slaughtering one of the suspected animals and examining the intestines for nodules. The veterinary expert may make an equally sure diagnosis by merely examining the dung under the microscope. Owing to their large size the ova can be seen with a low power in dung mixed with water in a shallow glass tray. In order to make sure, the ova must be measured, and the best plan will be to arrange the camera lucida so that it gives 440 diameters, and to compare the outline with the drawing given in the plate.

Treatment is, from the nature of the case, almost hopeless. No vermifuge can be expected to exercise any effect on the encysted worms, and it is by these that the main part of the mischief is effected.

The adult worms could probably be expelled by means of thymol; but it may be doubted if they do sufficient harm to make it worth while to attempt their expulsion. Apart from which, the value of a sheep in bad condition would, in India, be but little in excess of the cost of the dose.

Prevention.—In this direction too the outlook is not hopeful. It would not pay to cut grass for sheep, and, as it is impossible to prevent their depositing their droppings on their grazing ground, the only possible method of prevention lies in the detection and prompt slaughtering of all infected animals; but, owing to the ability of the species to exist continuously as a free nematode, this would have to be supplemented with periodical burning of grass on pastures, and would have to be persisted in for a long time before any great results could be expected.

The meat, such as it is, is in no way rendered unsuitable for food, and, as the sheep cannot be expected to improve while harbouring this parasite, the sooner they are slaughtered the better for the pocket of the sheep-owner.

As anything like systematic inspection of flocks, however, would be difficult, even in the most highly civilized of countries, and is entirely out of the question under the conditions of Indian agriculture, I think the most that can be done is to encourage grass-burning before the rains. Such a procedure would inflict a severe check on the mutiplication of the free stage of the species, and would at least give the lambs a fair start on uninfected pasture.

Curtice suggests stall-feeding, and this would, no doubt, be useful, provided

the fodder be obtained from localities over which sheep are not allowed to range, without which precaution it would be obviously useless. Where expense and trouble is not so great an object, as in the case of mutton clubs, this expedient, combined with disinfection of the fodder by heat, might be tried, and would be specially worthy of trial in localities like Assam, where mutton is a nearly unobtainable luxury, as I believe, mainly owing to this disease.

Conclusion.—It will, I think, be admitted that the facts that have been adduced in these two papers are sufficient to show that the damage to live stock wrought by parasites is much greater than has hitherto been suspected, and that many apparently inexplicable epizootics may be due to their ravages.

There is a strong tendency, even among professional men, to ignore the power of mischief possessed by intestinal parasites, and to treat as "only worms" organisms which live on the blood of their victims, and riddle their tissues to a sieve. While it is sufficient to discover a bacterium visible only under the best oil immersion lenses for the majority to be convinced that we have there the *causa causans* of the disease with which it may be associated, it is quite otherwise with animal parasites large enough to appeal to the naked eye, armed though they be with fangs and borers formidable enough to conduct phlebotomy, artenotomy, and other disagreeable surgical procedures to any extent that their insatiable appetites may suggest.

Let it not be imagined that the writer undervalues the morbific powers of the bacteria; but in medicine, as in other things, the influence of fashion comes in, and we live, just at present, in a bacteriological era in which it is hard to obtain a hearing for any other source of disease.

We want no more than the now classical example of anthrax to show us that animals, as well as men, fall victims to diseases caused by bacterial poisons, but all cattle disease is not anthrax, nor does it follow that because we may find micro-organisms in association with disease that they stand to each other in the relation of cause and effect. It is a characterstic of helminthiases that they may be combated by the most rudimentary sanitary measures; and hence it is that there are but few parts of the world left where the entozoa constitute any serious danger to man. But it is quite otherwise with animals, whose natural habit of indiscriminately fouling the soil defeat the most laborious efforts of man in the case of domestic species to keep them in cleanly condition. Hence, even in Europe, the losses from parasitic disease among domestic animals are still serious; and I am convinced that for cattle in India helminthological investigation is far more urgently needed than bacteriological research.

G. M. GILES, M.B., F.R.C.S.,
Surgeon, Indian Medical Service.

SANAWAR:
The 26th November, 1891.

Post scriptum.—While the above has been in the press, I have made the further discovery that encysted Œsophagostoma may be found also in by far the larger proportion of carcases of oxen that I have been examining. The species, however, evidently does not find itself at home in bovines, for the tumours remain for the most part small, comparatively few going on to the caseous stage, though the total number present has been very large, in one or two cases. The trichonemes, after escaping from encystment, however seem quite incapable of developing within the sloppy surroundings of the bovine colon. At any rate, the most careful search has failed to bring to light a single adult or even maturing specimen. I hope to deal more fully with this point at some future opportunity.

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Surgeon, Indian Medical Service.

SANAWAR :
The 30th December 1891.

Explanation of Plate.

A FIG. 1. *Œsophagostoma columbianum*, Curtice.

Head × 280 diameters. The two padillæ which serve as openings of the lateral canals are seen on either side. Of the other four tubercles, only one is shown, to avoid confusing the outlines of the armature

„ 2. Split preparation of the head of the same × 280 diameters showing, first, a ring of plates with semilunar ends, next the circlet of fimbriæ, and lastly, the circlet of bidentate teeth, below which is the wide œsophagus.

„ 3. Bursa of male *Œsophagostoma* partially spread × 70 diameters.

„ 4. Ovum of *Œsophagostoma* × 440 diameters taken from the clot adhering to the vulva.

„ 5. Trichonema stage of *Œsophagostoma* from tumour of intestine of sheep.

„ 6. A portion of the large intestine of a sheep affected with nodular disease of the intestine. Natural size.

B. *Trichosomum verrucosum*, sp. n.

„ 7. *Trichosomum verrucosum*, ♀, natural size.

„ 8. Head of the same × 28 diameters.

„ 9. Caudal extremity of the same × 28 diameters—

a—anus.

v—vulva.

u—uterus.

i—intestine.

„ 10. Ovum of above, from uterus × 440 diameters.

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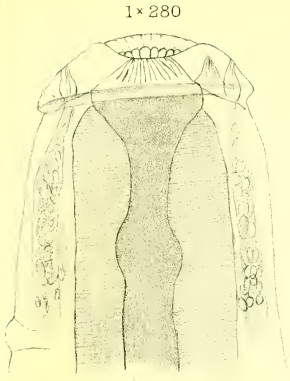

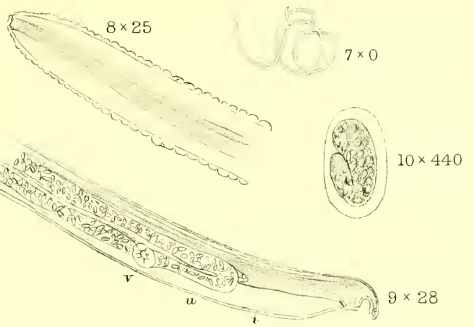

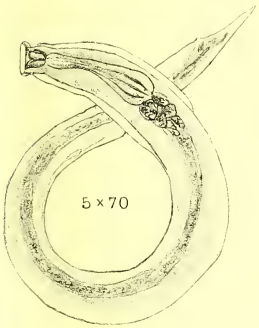

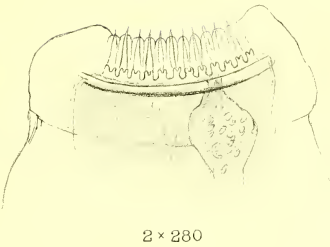

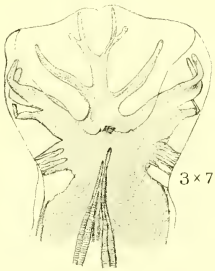

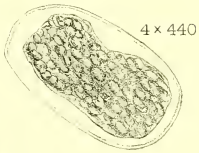

Litho., S. I. O. Calcutta.